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MINING METHODS OF THE ROSICLARE LEAD AND FLUORSPAR MINING CO., ROSICLARE, ILLINOIS

BY

A. H. CRONK

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UNDERGROUND MINING PRACTICE AND COSTS OF A FLUORSPAR MINE AT ROSICLARE, ILLINOIS[1]

By A. H. Cronk[2]

This paper is one of a series being prepared by the United States Bureau of Mines on mining methods and costs in the different mining districts.

The mining methods described in this paper are employed by one of the large mines in the Illinois fluorspar district. The mine is located at Rosiclare, Ill., and shipments are made over the Illinois Central Railroad and by barge on the Ohio River.

HISTORY

The Illinois-Kentucky fluorspar district is in Hardin and Pope Counties, Ill., and Crittenden and Livingston Counties, Ky. These counties border the Ohio River. Rosiclare, located on the Ohio River in Hardin County, is the center of the Illinois fluorspar mining district, while Marion serves the Kentucky field. The Illinois mines are in close proximity to the river, but the Kentucky operations are inland about 15 miles.

Lead mining was started in Hardin County in about 1842. At that time fluorspar had no commercial value, and it was not until about 1870 that the first shipment of fluorspar was made from this district. Since then it has been a constant producer. Shallow shafts were sunk along the Rosiclare vein and only the richer portions mined. The glass industry created the first demand for fluorspar, for manufacture of opalescent glass, enamels, and hydrofluoric acid. The use of fluorspar as a flux in the basic open-hearth steel process started about 1898, and the rapid development of that process created an increased demand for the mineral. Mining on a fairly large scale started about 1910, when systematic methods of mining and milling were employed.

USES OF FLUORSPAR

Fluorspar is used as a flux and cleansing agent in the basic open-hearth steel process and in the manufacture of hydrofluoric acid, artificial cryolite, ceramic products such as opalescent glass, enamel and sanitary ware, vitrolite, etc. The steel industry consumes about 85 per cent of the fluorspar produced and the remaining 15 per cent is used by the other industries cited above. The steel industry demands a gravel spar having an analysis of about 85 per cent calcium fluoride and not over 5 per cent silica. The ceramic grade is a ground fluorspar containing 96 to 98 per cent calcium fluoride and 1.5 to 2.5 per cent silica. The acid grade has an analysis of 98 per cent calcium fluoride and not over 1 per cent silica, and is shipped in both ground and lump form.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6384."

[2] One of the consulting engineers, U. S. Bureau of Mines, and superintendent of the Rosiclare Lead & Fluorspar Mining Co.

GEOLOGY

The rock formations of the Illinois fluorspar district are of Devonian, Mississippian, and Pennsylvanian age and consist of shales, sandstones, and limestones. The Mississippian series predominate, while the Pennsylvanian rocks are found only on the higher ridges or where extensive faulting has brought them into juxtaposition with the older formation. The Devonian outcrops are mostly shales and limestones, occurring in a dome structure in the west-central part of Hardin County. The Pennsylvania coal measures occur north of Hardin County. The rock formations are approximately horizontal with local dips and are faulted very extensively into irregular blocks. A few igneous dikes, sills, and plugs are to be found in the district.

The faults are all normal faults, and no thrust faults have been identified. The faulting was caused by extensive doming, caused possibly by deep-seated igneous intrusion followed by collapse or readjustment of the surface after the settling of the igneous mass. The major faults have a NE.-SW. strike and are criss-crossed by faults of lesser lengths. The displacements vary from a few feet up to 1,500 feet. While horizontal slickensides have been found, no other evidence of any extensive horizontal movement exists. The mineralized veins commonly occupy the faults, though some mineralization has taken place along fractures where there has been no dislocation. In the vicinity of Cave-in-Rock, a commercial fluorspar deposit occurs in a blanket formation resulting from replacement of the limestone. A cross section of the main faults near Rosiclare is shown in Figure 1 with the geological formations.

The most productive veins are near Rosiclare, and occur along the Rosiclare Daisy, and Blue Diggings faults. The Rosiclare vein has been the most productive with a known length of about 3 miles. Exploration and mining have extended over a length of 2 miles and to a depth of 720 feet below surface. This vein is practically vertical, the maximum width of vein being 30 feet and the average about 6½ feet. The ore bodies are fairly continuous, some of the stopes having a length of 1,500 feet. The walls are firm to within 150 feet of surface, where weathering has taken place. Occasionally old water courses are encountered which contain mud and give considerable trouble in mining operations.

The Daisy and Blue Diggings faults are the next in importance. The Daisy vein dips to the West and the Blue Diggings to the East and are about parallel where explored on the Rosiclare company mining property. The relation of the three faults is shown in Figure 1.

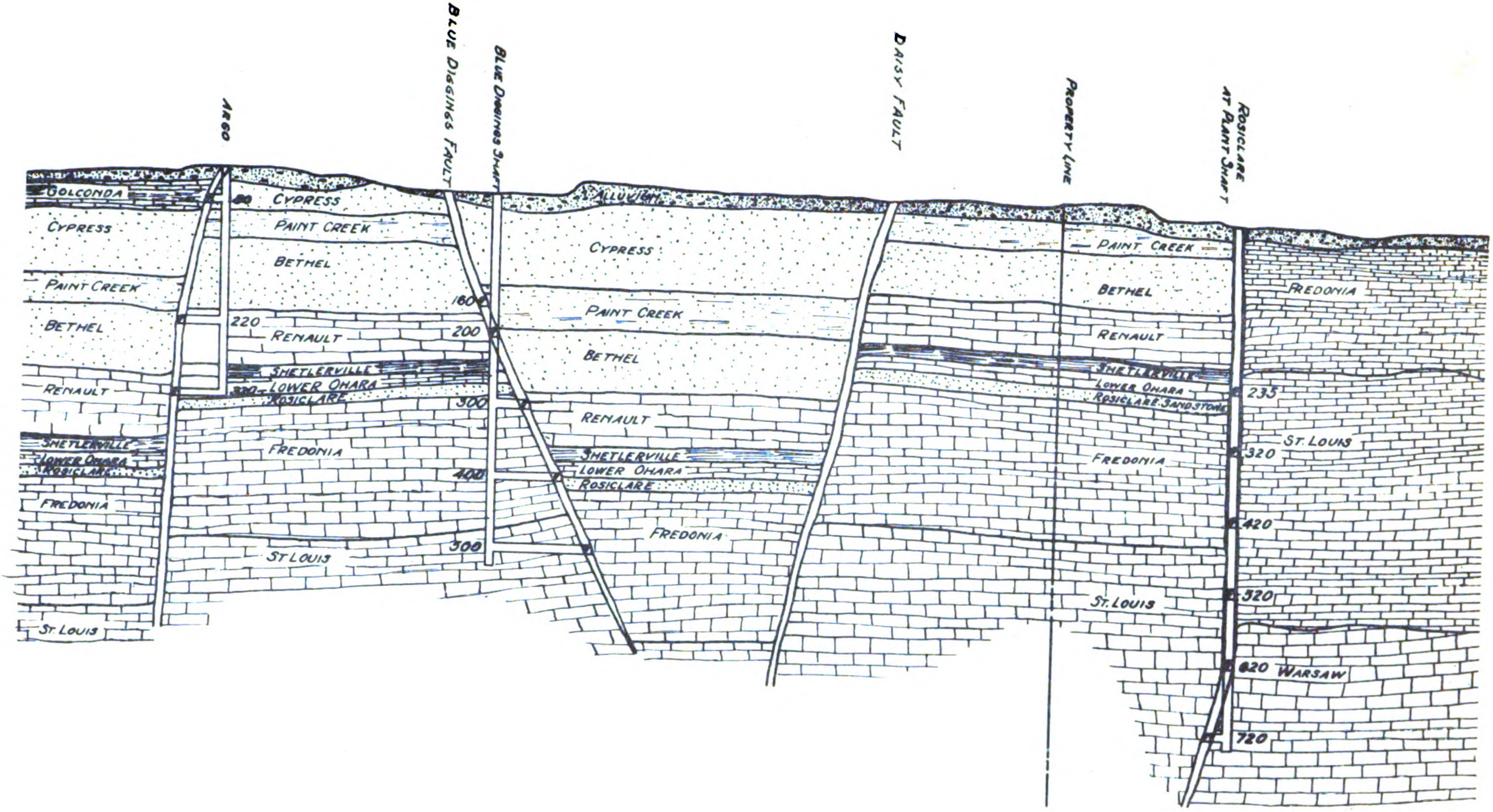

Figure 1.- Ideal cross section through Rosiclare, Daisy, Blue Diggings, and Argo faults

The ore occurs in lenses or pockets which have various lengths and widths from 2 to 30 feet and are separated by lateral and vertical pinches, usually without much mineralization. Considerable exploration work is necessary to locate new ore bodies and is accomplished by drifting and raising along the vein. The hanging wall is usually heavy, causing considerable contamination of the ore by sloughing off of large blocks of calcite, limestone, or shale. The upper portions of the veins are usually badly weathered, making it necessary to use timber for support of the hanging wall. The shrinkage stope system of mining is in practice below the weathered portion of the vein and no filling is used after withdrawal of the ore. The Daisy and Blue Diggings veins have been explored to a depth of 630 feet at the Daisy mine workings.

PROSPECTING AND EXPLORATION

The larger veins of fluorspar are found in the faulted zones, and hence prospecting is conducted where faults have been determined. The area has been well mapped by the Illinois Geological Survey in cooperation with the United States Geological Survey. The geological map is of utmost importance in prospecting. The location of a fault is generally recognized where two unlike formations--for instance, sandstone and limestone--lie in juxtaposition. Where the opposite sides of the fault are limestone there is difficulty in recognizing the fault. The presence of slickensided pieces of rock, quartzitic sandstone, decided change in color of the soil, sinkholes in good alignment are all indications of a fault. The finding of float fluorspar, galena, etc., on surface, outcrops of solid fluorspar, and associated minerals has resulted in locating ore bodies of considerable importance. This field is not unlike all other mining districts, where the native prospectors who have no knowledge of geology are sometimes successful in finding veins of commercial importance.

The faults are generally prospected by sinking shallow shafts with necessary crosscutting. Trenching across a supposed faulted zone is also of importance. Diamond drilling from surface has been done, but with varying success. This method is generally used for the location of the fault which can not be determined by rock outcrops.

The churn drill for prospecting purposes has not been used by this company. A mining company in this district employed the churn drill quite extensively for the location of unknown faults. Churn-drill holes were put down about 200 feet apart. A sample of the sludge was taken at frequent intervals, mixed with glue, and mounted on heavy drawing paper. The rock formations were determined and the log of the hole was drawn to scale with colors representing the different formations. Whether or not a fault existed could be easily determined by comparing the legend of the formations encountered by the churn drill. The cost of churn drilling varied from $1.50 to $3 per foot, depending on conditions.

Horizontal core drilling in the mine has been employed in locating faults. Diamond drilling can not be relied upon for blocking out ore reserves but is used primarily for the purpose of fault location to be followed by crosscutting, drifting, etc. Fluorspar is easily detected by the eye. Small representative portions are taken from the core when a fault is encountered that shows vein material and an analysis is made for calcium fluoride, silica, and carbonates. Diamond drilling costs about $2.50 per foot.

ORE ESTIMATION

Estimation of crude ore tonnages is made where the ore has been developed by drifts, raises, etc., the classification being proved, probable, and possible ore.

Proved ore is that which is blocked out on three sides, or when blocked out by two drifts not over 100 feet apart shows persistent widths of fluorspar. The occurrence of the ore body is taken into consideration. The ore bodies along the Rosiclare vein are more persistent in width both laterally and vertically while those along the Daisy and Blue Diggings veins are erratic, changing in width very suddenly. Ore blocked out on one side which shows persistent width is also classed as proved ore for an extension of 30 feet beyond the opening.

Probable ore is ore which may reasonably be expected to extend beyond the limits of proved ore.

Possible ore is ore which might occur beyond the limits of probable ore. The geologic structure, knowledge gained from drill holes, etc., always enter into consideration in calculating probable and possible ore. Generally no underground sampling is necessary, as the spar is easily recognized. The cubic foot factor per ton of ore in place is determined by the uniformity of the fluorspar in the stope or drift. If the ore is practically solid fluorspar, the factor of ten is used, and if intermixed with calcite, factors of 11 or 12 cubic feet per ton are employed.

GENERAL DEVELOPMENT

Methods of exploration, development, and mining operations described will refer generally to all of the mines operated by the Rosiclare Lead & Fluorspar Mining Co. The costs given in the report were taken from the Daisy mine, which has been the main producing mine since 1924, at which time the Rosiclare mine was flooded.

The Rosiclare mine, located on the Rosiclare fault in the village of Rosiclare, has been the largest single producer of fluorspar in the district. This mine has been a constant producer from the early days until the time of temporary shutdown on account of water conditions. The vein is practically vertical with exceptionally good walls to within 150 feet of surface. The ore is continuous with only short pinches of barren ground. The longest level was started 720 feet below surface. The main shaft was started many years ago in the vein with subsequent sinking as required during late years. The shaft is vertical and continues in the vein to the 620-foot level, below which the vein dips to the west. Levels are turned off at about 100-foot intervals for development and haulage drifts. The high flood stage of the Ohio River in 1913 covered the collar of the shaft. The 620-foot level encountered underground streams of water which could not be handled with the pumps and the mine was flooded in 1924. The estimated flow was about 3,500 gallons per minute. The mine was allowed to fill with water and the Daisy mine then was operated more extensively to furnish the required production.

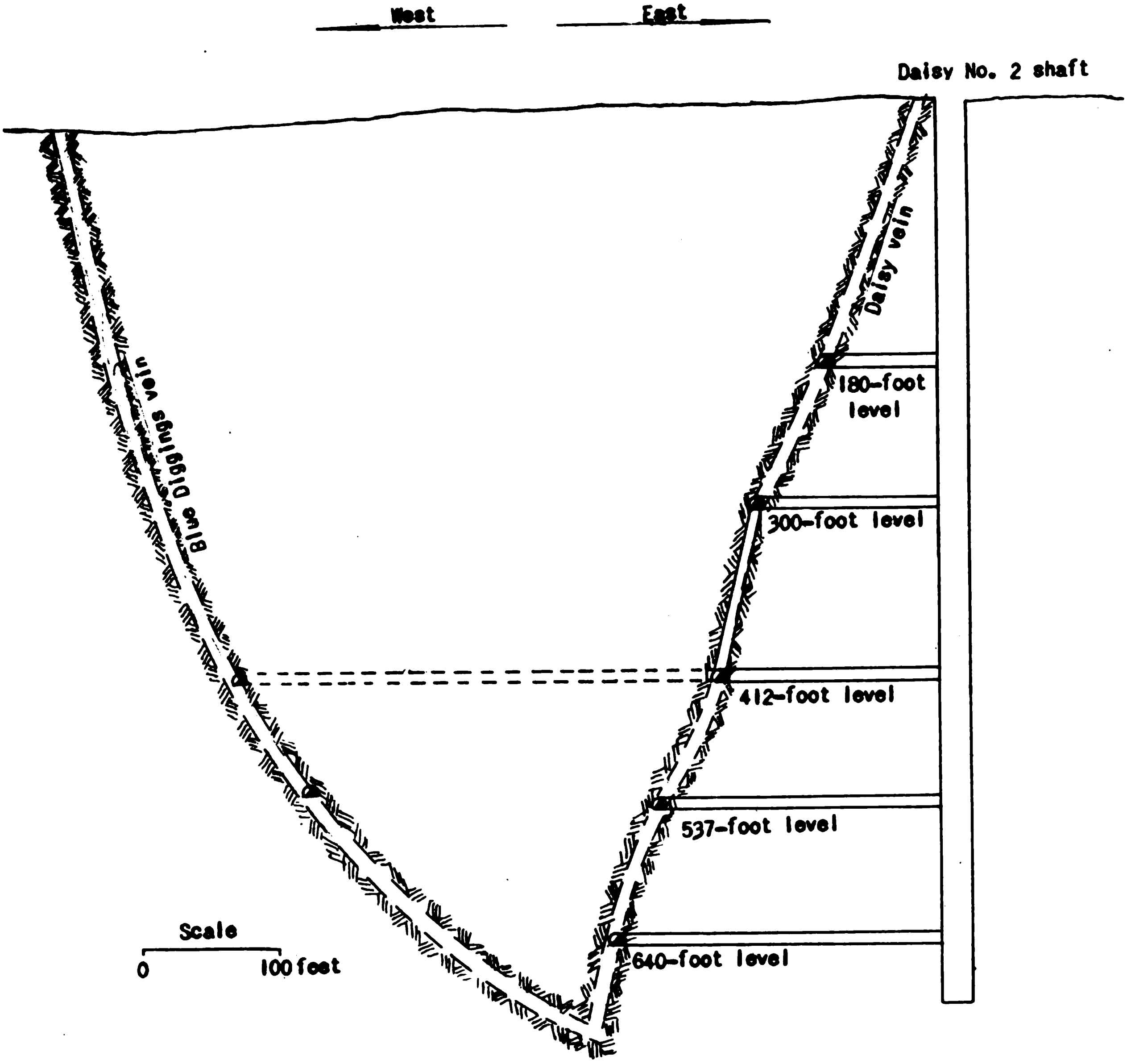

Figure 2.- Ideal vertical section through Daisy and Blue Diggings veins at No. 2 shaft

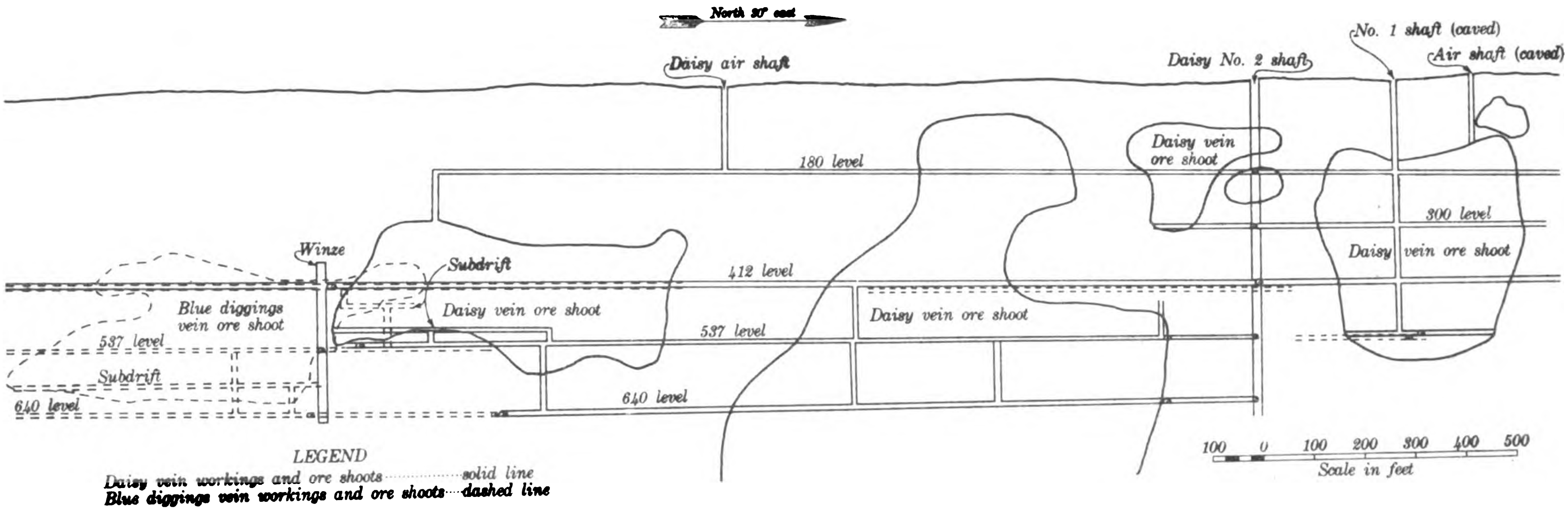

Figure 3.–Ideal longitudinal section of Daisy mine, showing main levels and general outline of ore shoots

DAISY MINE

The Daisy mine is located eight-tenths of a mile North of the mill and steam power plant. The Daisy vein and Blue Diggings vein are mined through the Daisy shaft. This shaft is 5 feet 6 inches by 15 feet inside the timbers and has now attained a depth of 612 feet to the lowest level, with a 50-foot sump below that level. The shaft was originally sunk to the 412-foot level in the footwall of the Daisy fault. A crosscut was driven at the 180 foot level to the vein to connect with a drift previously driven from an abandoned shaft. A crosscut also connects the shaft with an ore body on the 300 foot elevation. The main haulage level was driven at 412 feet. The crosscut from the shaft to the vein at this elevation is about 200 feet long (see fig. 2). The shaft is concreted to a depth of 90 feet, the remainder being solid rock requiring only 8 by 8 dividers for carrying the 6 by 6 guides, except below the 412-foot level, where considerable timbering was necessary due to the fractured condition of the limestone. The shaft has two hoisting compartments and one pump and ladder compartment. All of the hoisting is done with 3-ton skips operating in balance. The shaft is equipped with a steel headframe and an electric hoist. A well-equipped shop on surface handles all the sharpening of drill steel, picks, moils, and other tools.

Drifts and Crosscuts

The Daisy vein was developed by driving drifts on the 180, 300 and 412 levels. The latter was the main haulage level. This drift was driven both north and south along the vein. The drift is 7 feet high and generally is as wide as the vein. A minimum width of 6 feet is necessary to afford room for track, air lines, and drainage ditch. The ore bodies encountered were explored by raises and occasionally by winzes below the level (see fig. 3).

The 412 level was advanced about 2,000 feet south of the main shaft, at which location a crosscut was driven west to the Blue Diggings fault. This vein was thence developed by driving drifts north and south. A winze was sunk from the crosscut between the two veins to a depth of 225 feet. Crosscuts were turned off at 125 and 225 feet below the winze station, and the Daisy and Blue Diggings veins were developed at those elevations (see figs. 3 and 4).

The winze station consisted of an electric hoist with an ore and waste bin. All of the ore and waste was hoisted to this station and thence trammed to the main shaft by electric storage-battery motor. The 537 and 640 levels are also equipped with storage-battery haulage. The 537 level was driven north along the Daisy vein to develop the downward extension of the ore bodies encountered on the 412 level. Whenever an ore body showing on the upper level did not extent to the 537 level, a raise was driven to encounter the bottom of the spar. A subdrift was then driven to connect the main level with the subdrift (see fig. 3). The 537 level was continued to a point opposite the main shaft and a crosscut was driven to connect with the shaft.

At the 640 level a crosscut was driven from the winze to the Blue Diggings vein (see figs. 3 and 4). The vein was explored to the south by drifting and then to the north for a short distance; a crosscut was then driven to the Daisy vein, which was explored north to the main shaft, by another corsscut. The main shaft was then raised from the 537 level to the sump and sunk 50 feet below the 640 level. All the waste was hoisted through the pump compartment to the 412 level and dumped into the waste pocket. A station was cut out at the 630 level with waste and ore pockets. A typical station is shown in Figure 5.

The completion of the shaft to the 640 level eliminated the winze operation, thus allowing all the ore to be trammed direct to the shaft. Ore mined above the 537 level is dumped into raises connecting with the 640 level.

Most of the main levels, drifts, raises, winzes, and shafts are driven by contract. The miner is paid by the foot, depending upon the character of the ground. The contract for a drift is generally made with the machineman on each shift and covers all labor and explosives. The labor includes the helper and muckers. The muckers tram the cars by hand to the nearest switch. The drills used in drifts are Ingersoll-Rand N-70 drifters with $1\frac{1}{4}$-inch round steel. The standard cross bit is used with three changes in steel for drilling a 6-foot hole. The bottom cut round is generally used except where the vein has a slip along one wall, and then a side cut is used. The hardest ground to break is calcite, which, due to the interlocking crystals, makes a very difficult round to pull. This is generally accomplished by drilling more holes to depths of about 4 feet and using 50 per cent gelatin powder. In ordinary limestone and fluorspar, the round is easily broken and a bulk powder is used, manufactured by DuPont and known as Gelex No. 2, which has a strength of 48 per cent and 240 sticks per 100 pounds. Previously, before this type of powder was on the market, the special gelatin powder of 35 per cent strength was used, with 180 sticks per 100 pounds.

Drifts are generally 7 feet high and are carried the width of the vein. Wherever the fluorspar section of the vein is from 15 to 20 feet wide, the drift is driven 7 feet wide along one wall to the end of the ore body and the remaining 8 to 13 feet is slabbed. A typical cut is shown in Figure 6. The drills are mounted on column bars, and only one machine is used in the heading. All drifting is on a two-shift basis, and mucking is done by hand. An advance of about 200 feet per month can be made under favorable conditions with an average of 150 feet. The track is kept within 15 feet of the face. An ordinary drift in fluorspar required about 12 pounds of explosives per foot of advance. Three changes of $1\frac{1}{4}$ inch hollow round steel with lug shank and standard cross bit are used. The gage of starters is 2 inches, the second steel is 1-7/8 inches, and the finisher is $1\frac{3}{4}$ inches. The lengths are respectively 30 inches, 48 inches, and 72 inches. An average of 4 feet is broken per round. The air pressure is generally maintained at 90 to 100 pounds at the machine. The compressed air for the Daisy mine is supplied by compressors at the main plant. It is transmitted through a 4-inch line with a receiver at the mine. Air lines are $2\frac{1}{2}$ inches on the levels and stope lines are $1\frac{1}{4}$ inches.

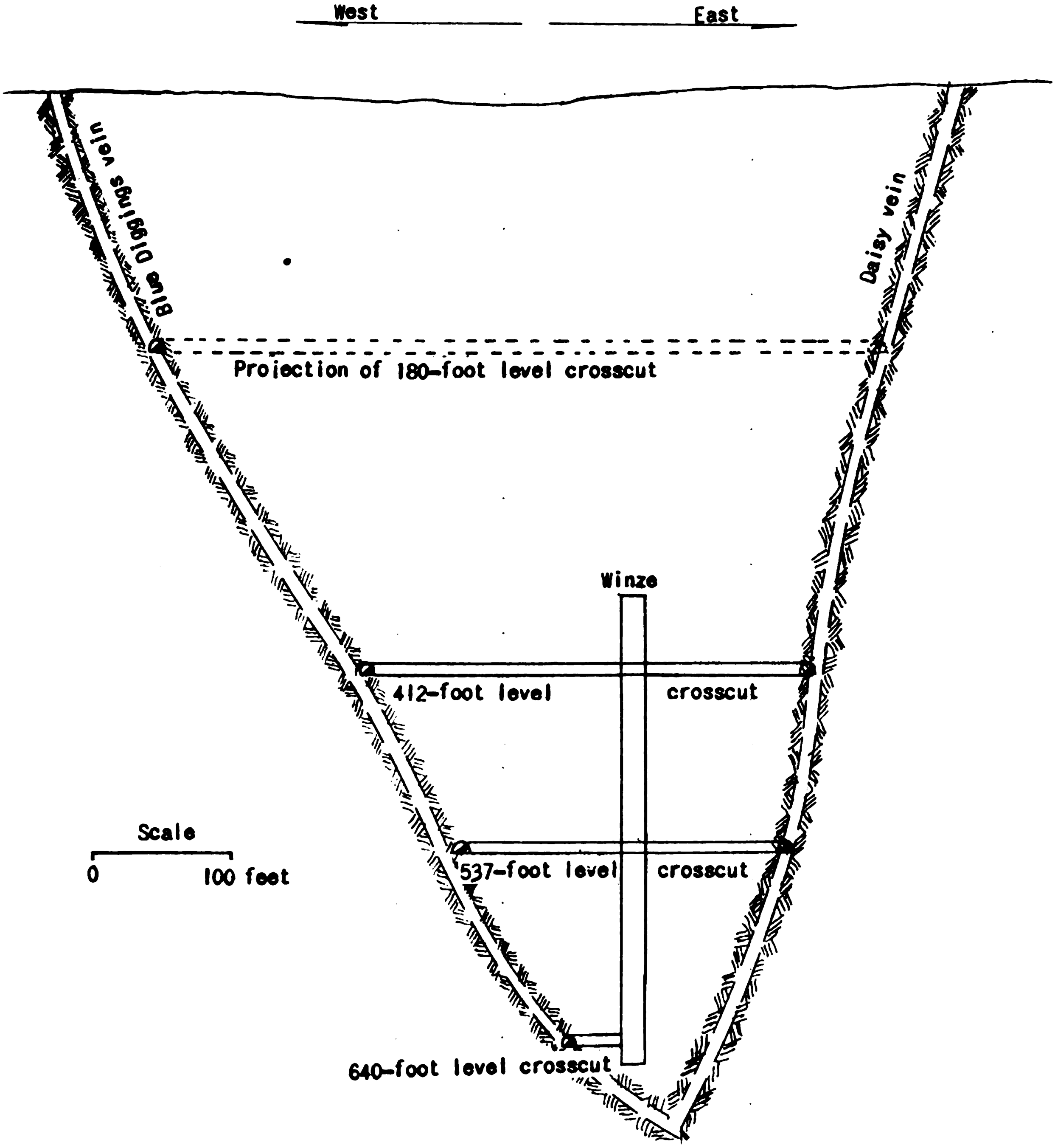

Figure 4.- Vertical section through Daisy and Blue Diggings veins at winze

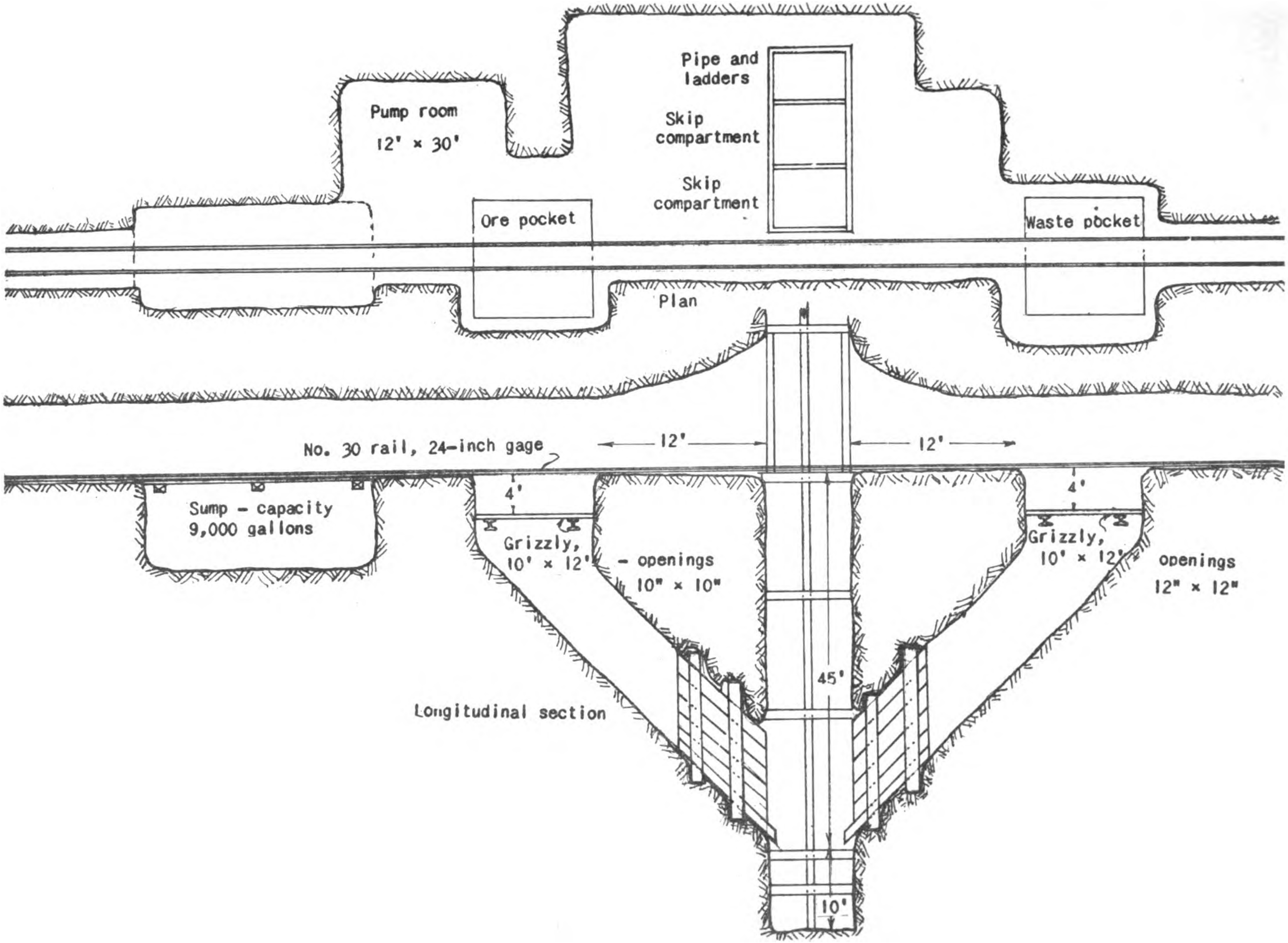

Figure 5.- Sketch showing plan and section of 412-foot level shaft station, Daisy mine

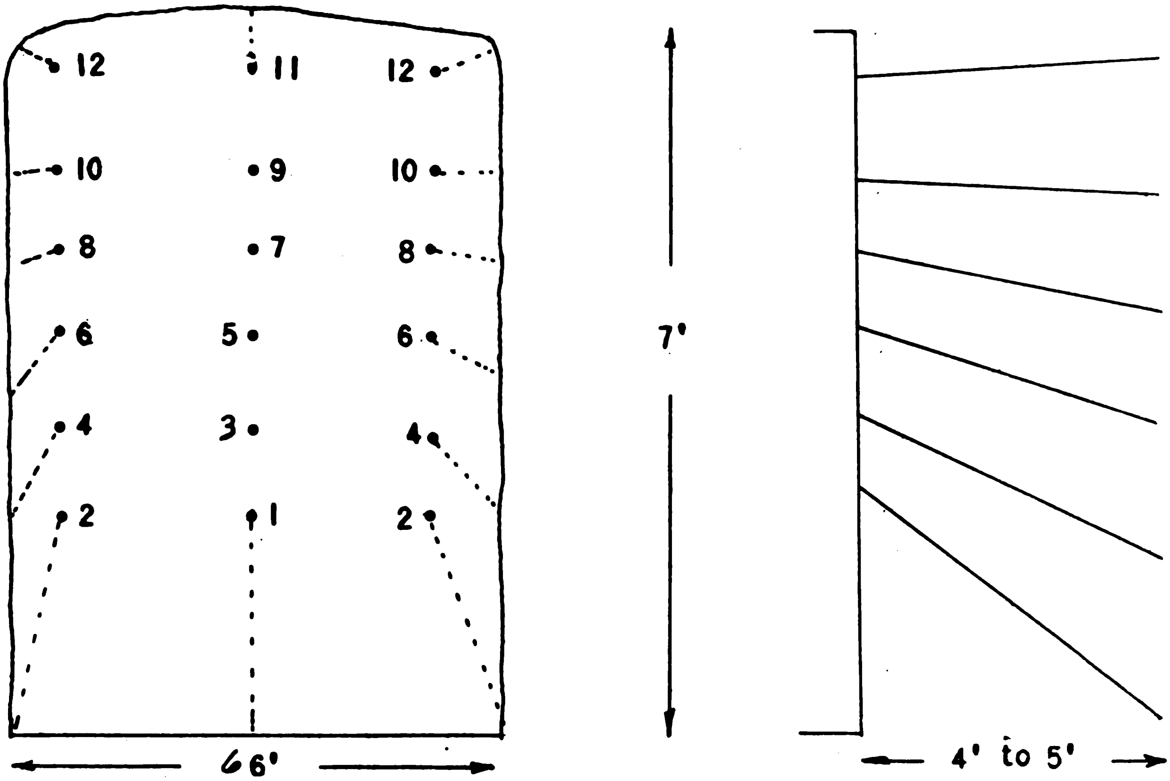

Figure 6.- Typical drift round; numbers indicate order of firing

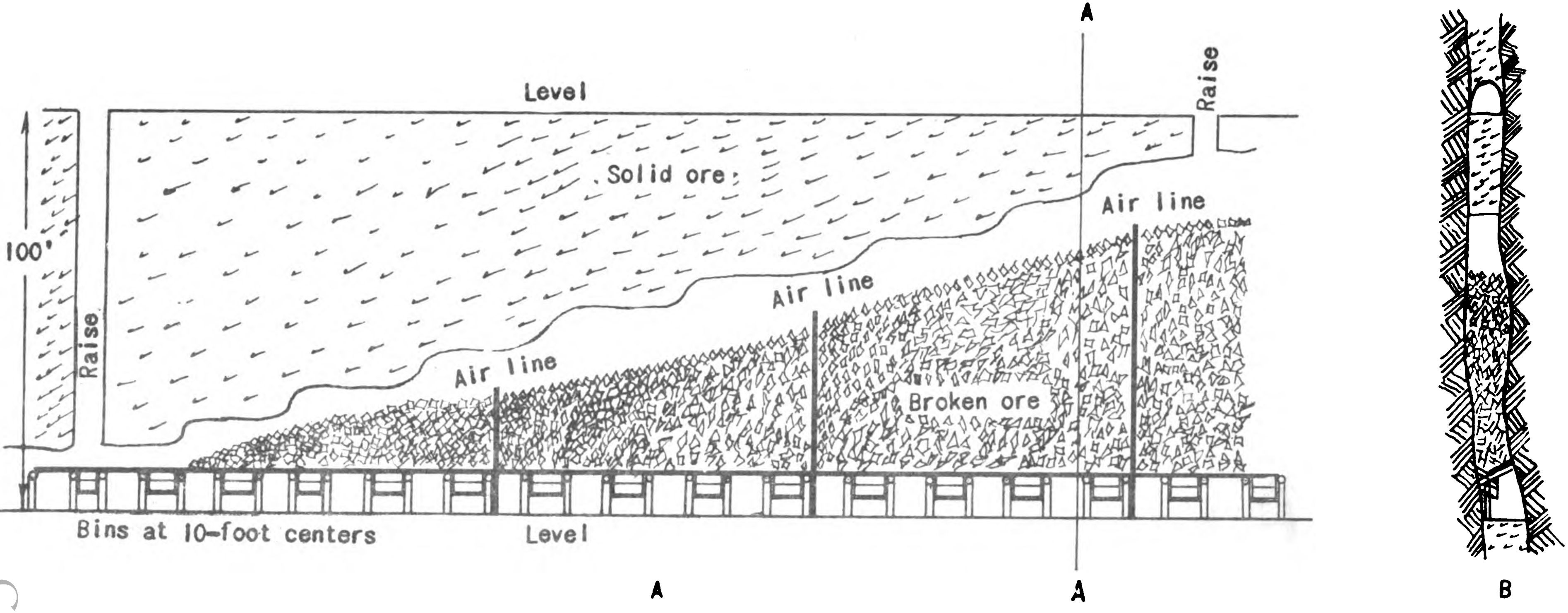

Figure 7.- Typical shrinkage stope: A, Longitudinal section; B, cross section

Raises

Raises driven in fluorspar are 8 feet long and the width of the vein. The ordinary "V" cut is used, and a light hand-rotated wet stoping machine is employed. Where the walls are firm, an open raise is driven. The only timbering used consists of working poles placed about 5 feet apart. Two men are employed in the raise, as the miner does his own timbering. A chute is built below the raise and no mucking is required. Where the walls are bad, the raise is driven as a filled raise. A bulkhead, consisting of small stulls and sawed lagging, is built about two-thirds from the end, over the chute. This part of the raise is kept filled with broken ore and the open part is used as a ladderway. For contract prices see section under "Wage and Contract System."

Stoping - Shrinkage Stoping

The walls of the vein are generally firm to within 150 or 250 feet of the surface and shrinkage stoping is employed below that elevation. Very seldom is any wall support necessary except where a large slab is encountered, and then a few stulls are used.

A typical shrinkage stope is shown in Figure 7. The drift through the ore body is about 7 feet high, making it necessary to take out a stope cut to give room for the stulls. This is done by a miner drilling out the back of the drift with a stoper and blasting the ore upon the track. The first stope cut brings the back about 12 feet above the bottom of the level, which is generally shot out the length of the proposed stope. From the top of the muck-pile, the miner generally drills out the second cut, but does not blast. This eliminates the necessity of putting in working poles. However, where the drift is required for immediate tramming purposes, the muck is cleaned up at once and working poles are placed to clear the motor and cars, from which the miner drills the second stope cut.

Hitches and headings for stulls are then cut in the footwall and hanging walls, respectively. Stulls are placed every 5 feet, and chutes are built on 10-foot centers. This arrangement is shown in Figure 8. The stulls are oak and vary in diameter according to the length. Round poles are placed on top of the stulls except over the chutes. The poles are from 4 to 6 inches in diameter and 7 feet long. Raises are driven to the level above near each end of the ore body. This is for ventilation and escapeway. Starting at one end of the stope the ore is shot down upon the poles and also fills the chutes. The miner then has enough room to stand on the broken ore and drills out the next stope. For an ordinary width of vein three holes are drilled across the back to a depth of 5 feet, and each row is spaced 30 inches apart. The sketch of the longitudinal section of stope shows the general progress. The shrinkage ore is kept drawn down through the chutes, leaving about 7 feet between the back of the stope and broken ore. Whenever a large slab is encountered on the wall it is either shot down or held by stulls, depending upon character of the wall. One end of the stope is advanced higher than the other, thus giving sufficient working places for drillmen. The end of the stope, where stoping operations started, is generally the dead end, while the opposite end is bulkheaded as the stope is advanced upward. The bulkhead is made of small stulls and lagged up and down with 2-inch lumber. A ladderway is always maintained on the bulkhead. Air lines are carried up along the footwall side and are 50 feet apart. The stope line is $1\frac{1}{4}$ inch pipe and is built up in 24-inch sections, pinned to the footwall with $\frac{1}{2}$-inch hooked rods. Whenever the end of the stope is wide and the walls are bad a cribbed manway or mill-hole is built up of poles. The stope is advanced to within 10 feet of the level above wherever that level is to be kept open. If the level is to be abandoned the bottom is shot out. Upon completion of the ore breaking, the ore is withdrawn as required to keep up production.

A miner is generally employed in the stope when the ore is withdrawn if the walls are firm and there is no danger from falling ground. He breaks up the missed boulders and slabs off any ore left on the walls. Where the walls are heavy the drawing of the ore starts at one end and is accomplished as fast as possible.

As the stope advances in the upper part of the mine the character of the walls changes. The footwall is solid, but the hanging wall is badly weathered. Wherever this condition occurs and both walls are solid the filled stope is discontinued and stulls are placed across the stope on 5-foot centers as a bearing for timbering the remainder of the stope. The Daisy vein under such conditions is not of sufficient width to carry out a regular square-set system. A half-set is generally employed, consisting of a stull the width of the vein hitched into the footwall and headed against the hanging wall with headboard and supported by a post to the stull below. The ore is shot down into the filled stope below and withdrawn through the chutes. The hanging wall is lagged with poles. A vertical slice about 15 feet long is generally carried upward to the top of the ore, where wide widths are encountered. This does not permit so much open stope to be carried as when a longitudinal section is taken out over the length of the stope.

Spacing the chutes on 10-foot centers eliminates practically all shoveling. The shrinkage ore can be withdrawn so as to give sufficient working space without hand-shoveling. There is no hand-sorting in the stope, but this is accomplished on the picking belt in the mill. Here all large pieces of waste rock and various grades of lump fluorspar are hand-sorted. The large boulders are broken in the stope by a sledge or shot, as condition demands. Sometimes in drawing the shrinkage from a filled stope, the broken ore has a tendency to arch over the chute and not to cave to the top. This makes a dangerous condition and a very close check is kept on the cars drawn. Whenever the ore remains arched a stream of water is forced into the broken ore and generally breaks down the arch.

The general practice outlined for opening a stope is varied whenever the level below the stope is to be kept open for several years or where bad wall conditions occur in an abandoned stope above, which would likely cave. Raises are put up every 20 feet to a height of 15 feet above the back of the level and are connected. The sides of the raise are shot out on about a 45° slope. This leaves a solid back pillar between which chutes are built. However, with this practice considerable trouble has been experienced in drawing the stope without shoveling.

This method is also followed where the vein is very wide. Chute raises are put in along the footwall side, thus using shorter stulls for chute support.

Light-weight hand-rotated stoping machines are used with 1-inch hexagon steel. Four changes of steel are used, as follows:

	Length, inches	Gage, inches
Starter	24	1-7/8
Second	36	1-3/4
Third	48	1-5/8
Fourth	60	1-1/2

The production of fines in the stope is one of the problems of blasting. Saving of the fine fluorspar in the gravity mill is difficult and hence the production of coarse lump at the mine is the ultimate aim. This has been accomplished somewhat by using only enough explosive to break down the ore without undue shattering.

Underground Haulage

The type of stope chutes is shown in Figure 8. The chute is built between alternate sets of stulls supporting the stope. The sides of chute are built of 2-inch and the bottom of 3-inch lumber. Hand-operated gate boards are used and are of 2-inch lumber held in place by wooden cleats. The inside clearance of chute is about 3 feet 6 inches.

The 537 and 640 levels are equipped with storage-battery locomotives. The cars are the common gable-bottomed side-dump type and hold about 1.25 tons of ore. The haulage on the 537 level is done by a 3-ton Mancha locomotive and the ore is passed to the 637 level through raises. The 637 level is the main haulage level to the shaft. A 1½-ton Mancha locomotive hauls the ore from the south end of the mine to within 1,000 feet of the main shaft. From here the ore is hauled to the shaft by a 3-ton Whitcomb locomotive which also hauls the ore from stopes above the 640 level on the Daisy vein.

The train of 10 cars is hauled to the ore pocket at the shaft and dumped by hand. The ore pocket is equipped with a grizzly, and a miner breaks all the larger lumps which will not pass the openings. The ore is hoisted in 3-ton skips operating in balance. Hand gates are used for controlling the loading of a skip. The general layout of the station arrangement is shown in Figure 5. The ore pocket and the waste pocket are on opposite sides of the shaft. The ore pocket holds 200 tons storage and the waste pocket about 100 tons. The surface bin is of wooden construction and holds about 75 tons of ore and 50 tons of rock waste.

Hand-tramming is employed in the subdrifts shown in the longitudinal section, Figure 3. Subdrifts are driven at bottom of ore bodies or where the main level does not encounter ore. A raise is driven from the main drift to the bottom of the ore body and a subdrift thence is driven in ore. The subdrift is used as haulageway for the ore mined above it. The ore is dumped into raises connecting with the main haulage level.

All track is 24-inch gauge, and 25-pound rails are used throughout the mine.

The main hoist has a double drum keyed together. The rope speed for hoisting ore is 600 feet per minute and the hoist is driven by a 150-hp., 2,300-volt, a. c. motor. The hoisting cable is 1-inch diameter.

Percentage of Extraction

The recovery of ore in the stopes is generally 100 per cent. Where the walls are firm there is no waste dilution; however, where the hanging wall is heavy in a shrinkage stope there is some dilution of ore by wall waste. In the timbered stopes there is practically no dilution.

These stoping methods have proved very satisfactory and will be employed to recover other ore bodies of similar character in the mine.

A small amount of waste is sorted on the grizzly of the ore pocket. The large pieces of waste are picked off and trammed to the waste pocket. All of the waste in the ore from 4-inch size up is discarded on the picking belt of the mill after a preliminary washing.

WAGE AND CONTRACT SYSTEM

The employees of the Daisy mine are paid by the shift except contract miners in stopes, drifts, and raises. The mine is in charge of a foreman, with a boss on each shift. The mine works two shifts of eight hours each, but no work is done on Saturday nights.

Head timbermen	$4.50 - $5.00
Timbermen helpers	4.00
Skiploader	4.00
Grizzlyman	4.00
Motor	4.00
Train loaders	4.00
Stopemen (Drillers)	4.50
Stope boulder breakers	4.00
Shovelers	4.00
Hoist engineer	4.00
Drift machine runner	5.00
Blacksmith	5.25
Blacksmith helper	4.00
Carpenters, surface	4.00
Laborers, surface	3.00
Waste sorters, surface	2.50

Contract prices for main drifts vary according to the character of the vein. When the vein is mostly fluorspar the price per foot is $7.50 which includes drillmen, muckers, and explosives. The price paid for driving in calcite is $8.50 per foot.

Exploratory sublevels are contracted for at $6. per foot and raises from $4 to $6 per foot, depending on conditions. Winzes for exploratory purposes in the vein cost about $10. Shaft sinking will vary considerably and will range from $25 to $40 per foot, depending upon the character of the rock and water encountered. Ore breaking in stopes also varies from 45 cents to $2 per ton, depending upon width of vein and whether it is a shrinkage stope or on open-timbered stope.

The ore broken in a shrinkage stope by a contractor is physically measured by the engineer at the end of each pay period. A survey is made of the stope during which the elevation of the back and widths of ore at every 10 feet are observed. This data is platted on a map from which the excavation made between pay periods can be calculated.

The open-timbered stope when contracted for is paid for by the car, as no broken ore remains in the stope.

Contract work includes all labor and explosive expense. It receives the same supervision as day-pay work. More tons per man are broken in stopes and better footage in drifts attained under the contract system.

VENTILATION

The Daisy mine has natural ventilation. An air shaft 1,500 feet south of the main shaft connects with the upper levels. The proper use of doors in the drifts, raises, etc. affords the necessary ventilation. Occasionally a small electrically driven blower is installed for ventilating a heading. Galvanized pipe of 10-inch diameter is used for the air conduit. Compressed air is used for blowing out smoke between shifts in drifts, crosscuts, etc.

FIRE HAZARDS

The fire hazard is practically negligible in the mine. Regular inspection of the mine is made to see that no inflammable material collects that would be a fire hazard. All empty powder boxes, rubbish, etc., are sent to surface. Most of the timbering in the mine is oak and as it is usually wet it is not easy to burn. The surface is well protected by fire extinguishers and water hose.

SAFETY METHODS AND FIRST AID WORK

Considerable effort and money have been devoted in the past few years to safety work. About 90 per cent of the employees have been trained in first-aid work. The initial training of the men was done by instructors of the Bureau of Mines rescue car. Several key men were then selected to act as instructors for training new men. The Illinois Mining Bureau has also assisted in helping to train first-aid men in the district. Four first-aid teams are kept in training and each department has several experienced first-aid men. First-aid kits are kept at important places in the mine. All openings in the mine are safeguarded by railings. Electric bell signals are used in hoisting and each signal is repeated by the hoist engineer. All miners carry their fuse and caps in a round metal container. Strict rules are enforced as to use of goggles and wearing of gloves. The bulletin board is used daily for accident records showing the safety standing of each department. The company belongs to the National Safety Council, and their safety bulletins are used to advantage. Regular monthly meetings are held by all foremen and shift bosses, and various safety suggestions are discussed.

The company has maintained a policy that all working places in and about the mine must be kept thoroughly clean. This takes constant effort, but the effect is reflected in the safety record.

Summary of Costs

Daisy mine, for year 1929.

Tons ore hoisted during year: 42,000.

Mining methods: Shrinkage and open timbered stopes.

Underground Costs per Ton of Ore Hoisted

	1 Labor	2 Supervision	3 Power drills & steel	4 Power hoisting, etc.	5 Explosives	6 Timber	7 Other supplies	8 Total
Development								
(1) In ore	0.357	.055	0.100	.022	.132		.066	.732
(2) In rock	0.225	.027	0.062	.012	.078		.029	.433
Mining	.710	.065	0.190	.080	.160	.120	.070	1.395
Transportation (underground) ...	.780	.020		.006			.010	.816
General underground expense ..	.300			.020			.020	.340
Surface expense (directly applicable to underground operation)	.14						.010	.15
Total	2.512	.167	.352	.140	.370	.120	.205	3.866

Summary of Costs in Units of Labor, Power, and Supplies

Daisy mine, for the year 1929.

Tons ore mined and hoisted: 42,000.
Tons of waste rock hoisted: 10,000.
Method of mining: Shrinkage and open timbered stope.

	Development and mining
A. Labor (man-hours per ton):	
Breaking (drilling and blasting)	1.60
Timbering (or), (and) filling	.25
Shoveling	.25
Haulage and hoisting	1.60
Supervision	.10
General	.20
Man-hours per ton	4.00
Average tons per man per shift	2.00
Labor, percentage of total cost	68%
Av. tons per man-shift on surface properly chargeable to underground operation	45
B. Power and supplies:	
Explosives (lb. per ton)	2.50
Timber (b.m., ft per ton)	6.00
Total power (kw.h.):	
(1) Air compression	9.0
(2) Hoisting	6.2
(3) Pumping	8.3
(4) Ventilation	0.2
(5) Lighting	1.0
Other supplies in percentage of total supplies and power	18.3
Supplies and power, percentage of total cost	32.0%

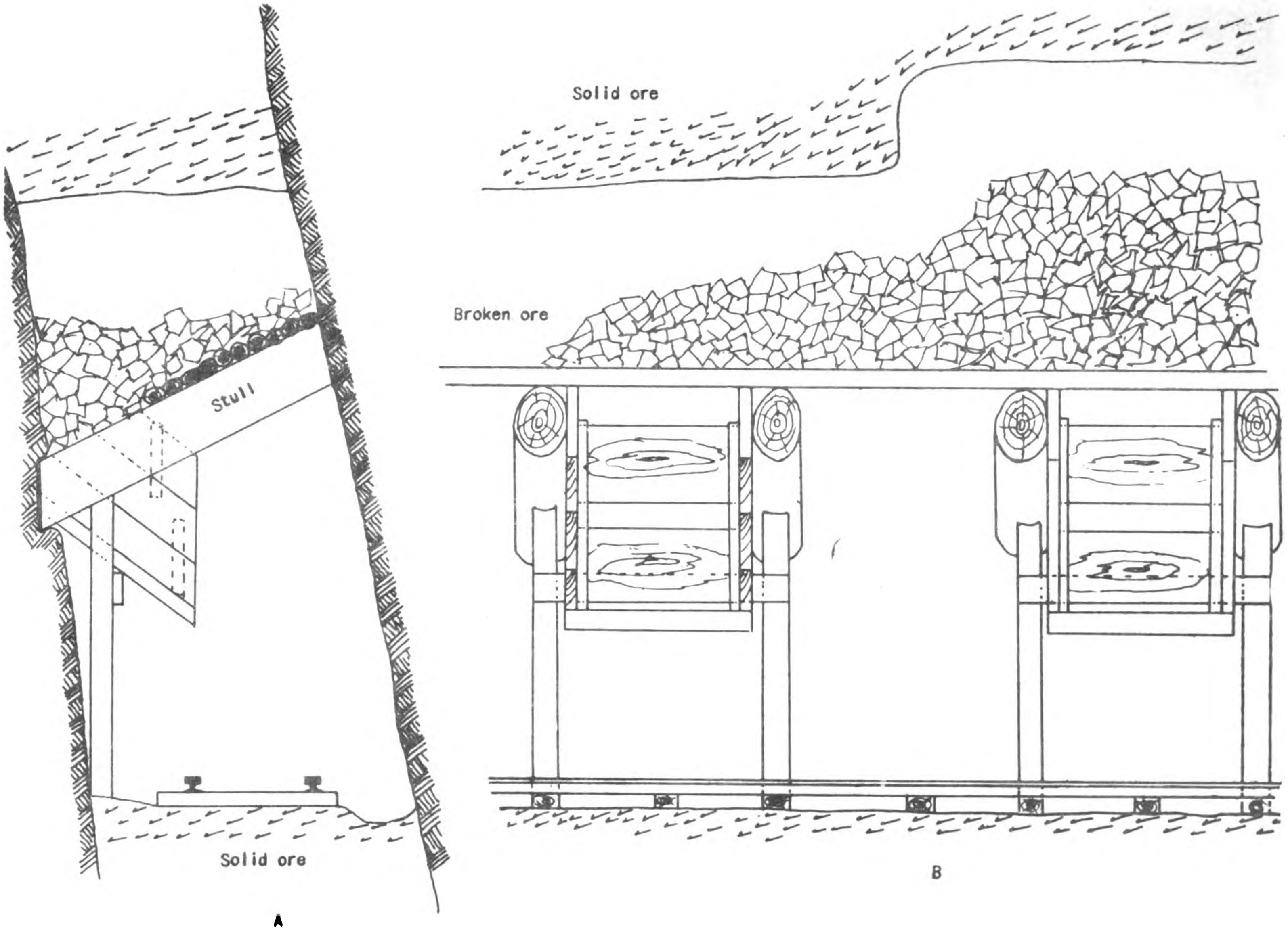

Figure 8.–Shrinkage stope showing arrangement of stulls and chutes: A, Cross section; B, longitudinal section